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ABSTRACT

This exploratory aptitude-treatment-interaction study hypothesized that various combinations of teacher types and treatment types have differential effects on different types of students. Teachers and students were clustered into types based on the similarity of their responses to a number of attitude and aptitude instruments. One-half of the teachers were selected to implement a treatment program which called for more active and direct instruction. All teachers were observed over a 16-week treatment period to insure that the treatment was implemented. Results of the analysis indicated significant interactive effects. (MP)

An Investigation of the Interactive Effects Among Student Types, Teacher Types, and Instructional Types on the Mathematics Achievement of Fourth Grade Students

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In the past two decades, much of the research on teacher effectiveness has concentrated on identifying what teachers can do to promote student achievement. The assumption underlying this research is that it is possible to identify variables that could be used to predict teaching effectiveness in general. By improving the teacher's skills on these selected variables, it has been assumed that one could improve the general educational program for all students. Yet, recent reviews of this research suggest that this view is too simplistic since there are few consistent findings (Rosenshine, 1971; Heath and Nielson, 1974) and very little that can be used to help teachers decide what course of action they should follow in the classroom (Dunkin and Biddle, 1974).

These research contradictions seem due, in part, to two factors. First, many investigators have failed to qualify their findings based on the context of their studies. Fourth grade mathematics is clearly different than high school English, and one would suspect that effective teaching strategies would not be the same across both contexts. Secondly, many researchers have ignored the existence of interactions among teacher characteristics, student characteristics and instructional strategies (Aptitude-Treatment-Interactions). It may be that neither the same instructional strategy nor any combination of teacher characteristics will prove to be optimal for all types of students. Treating all students alike in the research design may obscure important differential effects of teachers and instructional delivery systems on the achievement of different types of students (See Cronback and Snow, 1977, for a review of ATI studies).

Recently, however, researchers have begun to design studies to focus specifically on interactions between students and teachers, and/or students and instructional programs. Some investigators have concentrated on searching for interactions between a single student trait (e.g., dependence/independence) and various treatment programs, while others (Cummingham, 1975; Bennett, 1976; and Solomon and Kendall, 1976) have formed student and teacher types based on their

similarity across a number of traits. This latter procedure is an attempt to avoid the artificiality of either treating the trait as an isolated variable (ignoring possible joint or confounding effects of other variables) or of attempting to account for the simultaneous effects of numerous variables.

In addition to an increasing interest in student interactive effects, there have been additional efforts to specify and examine teacher effectiveness in defined contexts (e.g., first grade reading). Furthermore, attempts have been made to insure that relatively effective and ineffective teachers are included in study samples (See for example Good and Grouws, 1977; Brophy and Everston, 1976; McDonald, 1976; Berliner and Tikunoff, 1976).

In particular, sustained work at the fourth grade level in mathematics (Good and Grouws, 1975, 1977) has yielded a set of instructional behaviors that appears to differentiate more and less effective mathematics teachers. Furthermore, an explicit instructional model has been developed from this naturalistic program of research (Good et al., 1977). However, effectiveness in this program of research has been defined as average classroom growth. It is conceivable that the instructional model alone or in combination with various teacher characteristics could have important differential effects on different types of students. One purpose of this study was to test that possibility.

The second purpose was to further the ATI paradigm by combining the two approaches typically employed (student type interacting with teacher type and student type interacting with the instructional program) into a three-way model which simultaneously examined interactions among teacher types, student types and the instructional program.

METHOD

Sample

Thirty-nine fourth grade mathematics teachers who volunteered from a large southwestern school district were included in this study. Most of the volunteer teachers came from low SES schools. There were 68 sections of math taught by 39 teachers in 28 different schools. Twenty-five of the teachers had at least two years of experience teaching mathematics, and 14 had more than five years of experience. All of the teachers had taught in elementary schools, although not necessarily math, for at least three years.

Schools were used as the units for assignment to either the experimental or control conditions. All teachers at a particular school were assigned to the same treatment condition, either experimental or control, thus reducing possible confounding of the treatment and control conditions.

INSTRUMENTATION

Student Measures

To develop student typologies, an instrument (Attitude Inventory) was developed to assess various student attitudes which might interact with key features of the treatment program, definable teacher characteristics, and/or classroom procedures.

Two pilot tests of the instrument utilizing low SES students were undertaken. Items that showed little variation, little stability, or caused student confusion were dropped or modified. The final instrument consisted of 37 true-false questions and seven subscales. Operational definitions of the subscales follow.

1. Mental Computations - a student's self report of his like/dislike of doing mental computations independent of pencil and paper mnemonic devices.
2. Conscientiousness - a student's self report of his conscientiousness, such as completion of homework, keeping track of papers, and remembering what to do.
3. Choice - a student's self report of his preference for choice in his assignments and activities in math class.
4. Dependence - a student's self report of his dependence on the teacher for initial structuring of the math lesson.
5. Other Orientation - a student's self report of his like/dislike of working with other individuals to solve math problems.
6. External Motivation - a student's self report of his dependence on external forces (such as checking of papers) for motivation in math.
7. Misbehavior - a student's self report of the amount of trouble he gets into in school.

To establish the stability, the instrument was administered twice (with a two-week interval) to 62 students. The procedures for these two testing sessions were identical to the administration procedures used in the main study. Written instructions for administering the attitude inventory were given to each teacher to control for individual teacher differences. Although the instrument readability was determined by the Harris-Jacobson Readability Formula to be at grade level 2.4, teachers were instructed to read the questions to the students to overcome any possible student reading difficulties. Stability coefficients were calculated for each subscale (Cureton, 1958) and showed adequate two week test-retest reliability (the lowest stability coefficient was 0.644). Internal consistency (KR-20) of the subscales was determined using the student data from the main study

Table 1

Attitude Inventory Inter-Scale Correlations
(Internal Reliabilities on Diagonal)

	Mental Computations	Conscien-tiousness	Choice	Dependence	Other Orientation	Ext Moti
Mental Computations	0.768	0.274	-0.066	-0.149	0.153	-0
Conscientiousness		0.648	-0.107	0.033	0.193	-0
Choice			0.651	-0.093	-0.149	0
Dependence				0.478	-0.082	-0
Other Orientation					0.520	-0
External Motivation						0
Misbehavior						
Pre-SRA Achievement Score						

and is reported in Table 1, along with the inter-scale correlations.

Teacher Measures

To obtain teachers' views of the characteristics, organization, and typical activities of their classrooms, a questionnaire was developed (Teaching Style Inventory). Each item used in the questionnaire was selected because of its relationship to factors that previous research had suggested to be relevant to achievement in elementary mathematics. After numerous revisions and two pilot tests, a final version was developed which contained 73 questions divided into three sections. The first section contained 39 items assessing normal classroom procedures. Teachers were instructed to indicate where they would classify their classroom on a continuous scale with regard to specific classroom practices (amount of testing, emphasis on enjoyment, etc.). The second section, consisting of ten items, gathered information concerning the teacher's opinions, interests, and attitude regarding mathematics. The information was obtained by having teachers indicate agreement or disagreement (using a five-point scale) with a number of statements (e.g., "I feel I have a good sound background in mathematics; teaching math makes me feel secure").

The last section asked the teacher, in a fill-in-the-blank format, for specific quantifiable information, such as the number of days per week that he or she taught math. This section also included several open-ended questions that posed a particular instructional problem and asked teachers how they would resolve the dilemma.

Seven subscales were derived from the inter-question correlation matrix:[1]

1. Need for Personal Control - the teacher's expressed need to be in full control of the classroom events and rules

[1]Factor analysis was initially employed, however, the derived factors were difficult to conceptually define, therefore, an alternate procedure to factor analysis was employed. Questions were first grouped conceptually then submitted for reliability analysis. (See Nunnally, 1967)

2. Need for Contextual Stability - the teacher's expressed need for stability in the curriculum, classroom organization, and instructional pattern.
3. Degree of Individualization - the degree to which children were taught and evaluated as individuals
4. Degree of Abstractness - the degree to which the class was taught using abstract concepts or taught employing techniques or materials with which the students had little familiarity
5. Degree of Security - the degree to which the teacher felt comfortable and secure about her ability to teach math
6. Experience - the total number of years the elementary school teaching experience plus the number of years of experience teaching fourth grade mathematics.
7. Education - the total number of credit hours in mathematics plus the number of graduate credit hours

Internal consistency estimates of these subscales were determined in a manner analogous to the procedures employed with the attitude inventory instrument. Reliability results for five of the subscales as well as all interscale correlations are presented in Table 2. Since subscales six and seven were continuous in nature and represented factual information rather than opinions, calculation of reliability was precluded.

Dependent Variable

The blue level four ES mathematics subtest of the SRA Achievement Test series was the outcome measure, as well as the covariate (same test administered immediately preceding the experimental phase of the study). The test included 40 multiple choice items dealing with various topics traditionally covered in elementary math classes. The within-grade reliabilities (KR-20) was reported higher than 0.90.

Table 2

Teaching Style Inventory Inter-Scale Correlations
(Internal Reliabilities on Diagonal)

Subscale	Need for Personal Control	Need for Contextual Stability	Degree of Indivi-dualization	Degree of Abstractness	Degree of Security	Experience	Education
Need for Personal Control	0.540	0.027	-0.274	-0.065	0.067	0.289	-0.109
Need for Contextual Stability		0.727	-0.518	-0.078	-0.026	-0.075	-0.009
Degree of Individualization			0.772	0.015	-0.124	0.153	-0.023
Degree of Abstractness				0.636	-0.527	-0.059	-0.175
Degree of Security					0.606	-0.180	-0.036
Experience						--	-0.026
Education							--

A major criticism of using standardized tests as the outcome measure is that they may lack content validity if there is no relationship between what is "taught" and what is "tested" (Gall, 1973). To establish content validity, each teacher's lesson plan was examined to see how closely the material covered matched the content tested on the SRA Achievement Test. Results of the examination revealed that all the teachers had covered most of the mathematics material that the SRA achievement tested. Additionally, the experimental and control teachers had covered roughly the same material, and thus, were approximately equal in terms of teaching the material that the SRA test covered. Hence, there existed no apparent interaction between the treatment condition (experimental and control) and the content coverage of the SRA Achievement Test.

Observation System

To insure that the treatment was implemented, an observation system was employed. Four trained coders observed each teacher at least five times. The process measures used were essentially those utilized by Good and Grouws (1975) in a study of process-product relationships in fourth grade mathematics classrooms. Four basic sets of information were gathered. First, time measures were taken to describe how instructional time was utilized. Secondly, low inference descriptions of student-teacher interaction patterns were gathered using the Brophy-Good Dyadic System (1970). Thirdly, high inference data were obtained by use of variables drawn from the works of Emmer (1973) and Kounin (1970). Finally, checklists were used to describe math materials, assignments, and pacing information.

Treatment

The treatment program was basically derived from earlier naturalistic research conducted by Good and Grouws (1975, 1977). They identified fourth grade teachers who consistently were more or less effective in obtaining mathematics achievement. Observation in these classrooms produced a set of behaviors that consistently separated more and less effective teachers. In the present study, the

naturalistic findings from Good and Grouws (1975, 1977) were integrated with the recent research of others and translated into an instructional program (see Good and Grouws, et al., 1977 for a more detailed description). The treatment program basically encouraged teachers to make six adjustments in their instructional patterns.

1. Development - to devote approximately one-half of the mathematics class period (about 20 minutes) toward developing conceptual understanding of mathematics
2. Homework - to assign and grade problems to be completed by the students at home
3. Process/Product Questions - to ask more questions calling for knowledge of a specific "fact" such as the answer to a particular mathematical problem (product question) and fewer questions assessing understanding (process questions)
4. Seatwork - to allow only 10-15 minutes per day for practice and observe the following principles during that session:
   a. on task - providing uninterrupted successful practice
   b. momentum - keeping the students working
   c. alerting - letting the students know they will be held accountable
   d. accountability - actual checking of students' work
5. Review/Maintenance - to conduct regular review sessions once every week for one-half of the math period and once each month for the full mathematics period
6. Pace - to carefully consider the rate in which material is covered and increase the pace if possible

Procedure for the Study

In the early part of September, 1977, the 39 fourth grade mathematics teachers, who volunteered to participate in the study, attended an inservice workshop. During the workshop, the teachers filled out a questionnaire regarding their styles of teaching mathematics (Teaching Style Inventory). All teachers were told that although the experimental program was expected to work, the program was based on correlational research, and the project was a test of these ideas.

Teachers in the experimental group were given an explanation of the treatment program and a 45-page manual along with instruction to read it and begin to plan for implementation. Control teachers were told to teach as they normally would and that they would not get the details of the program until February.

Importantly, a deliberate effort was made to create a strong Hawthorne effect in the control group to maximize confidence in believing that any subsequent differences between experimental and control groups would be due to program differences, not motivational differences. Given that control teachers knew that the research was designed to improve student achievment, that the school district was interested in the research, and that they were being observed and would receive feedback, it appears reasonable to assume that a strong Hawthorne effect for the control teachers was created. This was subsequently verified by the SRA post-test information that shows that the control teachers' students' achievement had grown seven months during only four months of the program.

For the next fifteen weeks, the coders observed and recorded classroom events in all 39 teachers' classrooms. Observations were approximately equally spaced although some adjustments were necessitated by physical restrictions including illnesses, assemblies, distances between schools, etc. Observation was terminated, and the post SRA Achievment Test was administered in mid-December.

Statistical Methods of Analysis

Cluster Analysis (SAS, 1976), a multivariate procedure, was selected to group student and teachers into types that were maximally similar within types, but maximally different between types. Teachers were clustered into types based on the likeness of their responses on the subscales of the Teaching Style Inventory. Because of the wide range of their responses on the subscales, the scores for each teacher were standardized (mean = 0 and S.D. =1) before they were entered into the cluster program. This prevented one subscale from exerting undue influence on the resultant clusters.

Since the number of students in this study far exceeded the maximum number of observations that can be grouped using any computer clustering program, a procedure suggested by Overall and Klott (1972) was employed. The algorithm calls for the clustering of random subsamples, subsequently followed by a clustering of the clusters.

A computerized random number generator (SAS, 1976) was employed to produce ten random subsamples from the total sample of students (N=1097). Variables entered into the clustering procedures included those seven attitude factors derived from the attitude inventory plus student sex and the pre-SRA math achievement score. The initial cluster analysis produced a total of 50 student clusters. The 50 clusters were then entered into a second order cluster analysis using within-cluster means on the various components.

Multiple-regression analysis (SAS, 1976) was used to remove the pre-math achievement effect on the criterion variable prior to further analysis. The criterion for student success was defined as the difference between the observed and predicted scores on the SRA Mathematics Achievement Test.

Since the data fulfilled the necessary assumptions, three-way analysis of variance (SAS, 1976) was used to investigate the separate and joint effects of the

Table 3

Student Types Based on the Cluster Analysis: Means, Standard Deviations and F Ratios for Cluster Components

Student Typology		Components								
		Mental Computations	Conscientiousness	Choice	Dependence	Other Orientation	External Motivation	Behavior	Sex 1=Male 2=Female	SRA Pre-Achievement Score
One (N=388)	Mean	2.46	7.32	1.11	4.44	1.87	4.55	0.50	1.55	10.97
	S.D.	1.47	1.87	1.22	0.69	1.18	1.23	0.83	0.49	1.80
Two (N=214)	Mean	2.69	7.40	1.89	4.09	1.95	3.66	0.70	1.55	17.19
	S.D.	1.48	2.07	1.51	1.18	1.39	1.65	0.97	0.49	3.22
Three (N=344)	Mean	2.72	6.13	1.90	3.91	1.50	4.90	0.65	1.49	6.70
	S.D.	1.35	2.29	1.47	1.10	1.10	1.15	0.91	0.50	2.24
Four (N=151)	Mean	3.29	8.82	0.78	4.18	2.24	3.66	0.27	1.35	20.86
	S.D.	1.19	1.08	0.98	0.96	1.32	1.52	0.70	0.48	5.62
Total (N=1097)	Mean	2.70	7.17	1.46	4.17	1.82	4.36	0.55	1.50	12.21
	S.D.	1.40	1.97	1.33	0.97	1.22	1.34	0.87	0.49	3.01
F Ratios (3,1093 df)		12.60*	68.60*	41.08*	18.71*	14.55*	54.37*	8.95*	6.41*	1009.42*

*p<0.001

independent variables on the outcome measure. The residual scores on the SRA Mathematics Achievement Test served as the dependent variable, while student type, teacher type and treatment type constituted the independent variables.

Student Types

The cluster analysis procedure described above resulted in four distinct student typologies. The cluster profiles composed of the component measures and standard deviations are included in Table 3, as are the F ratios, indicating the degree to which each component differentiates the cluster or student typology. Student typology profiles, which are based on standard scores on each of the components, are presented in Figure 1. Descriptions of the four student typologies follow.

Student Type One

Students in this cluster scored slightly below the average on prior math achievement. They displayed an average conscientiousness in completion of papers and assignments and needed only moderate adult encouragement to complete their work. Behavioral problems were reported as moderately low in frequency. In general, type one students could be classified as "typical" in most respects. The key characteristic that distinguishes type one students from all other types is that they appear to be very dependent on the teacher for direction and guidance. Their scores, for instance, on dependence (most dependent of all student types) and choice (prefer little choice) are clear indicators of dependency. Additional support for the dependency label is the finding that these students dislike mental computations (where they are asked to do calculations on their own). This typology appears to represent children who are average in most respects except for their dependency on the teacher for direction and structure. Student typology one has been labeled dependent.

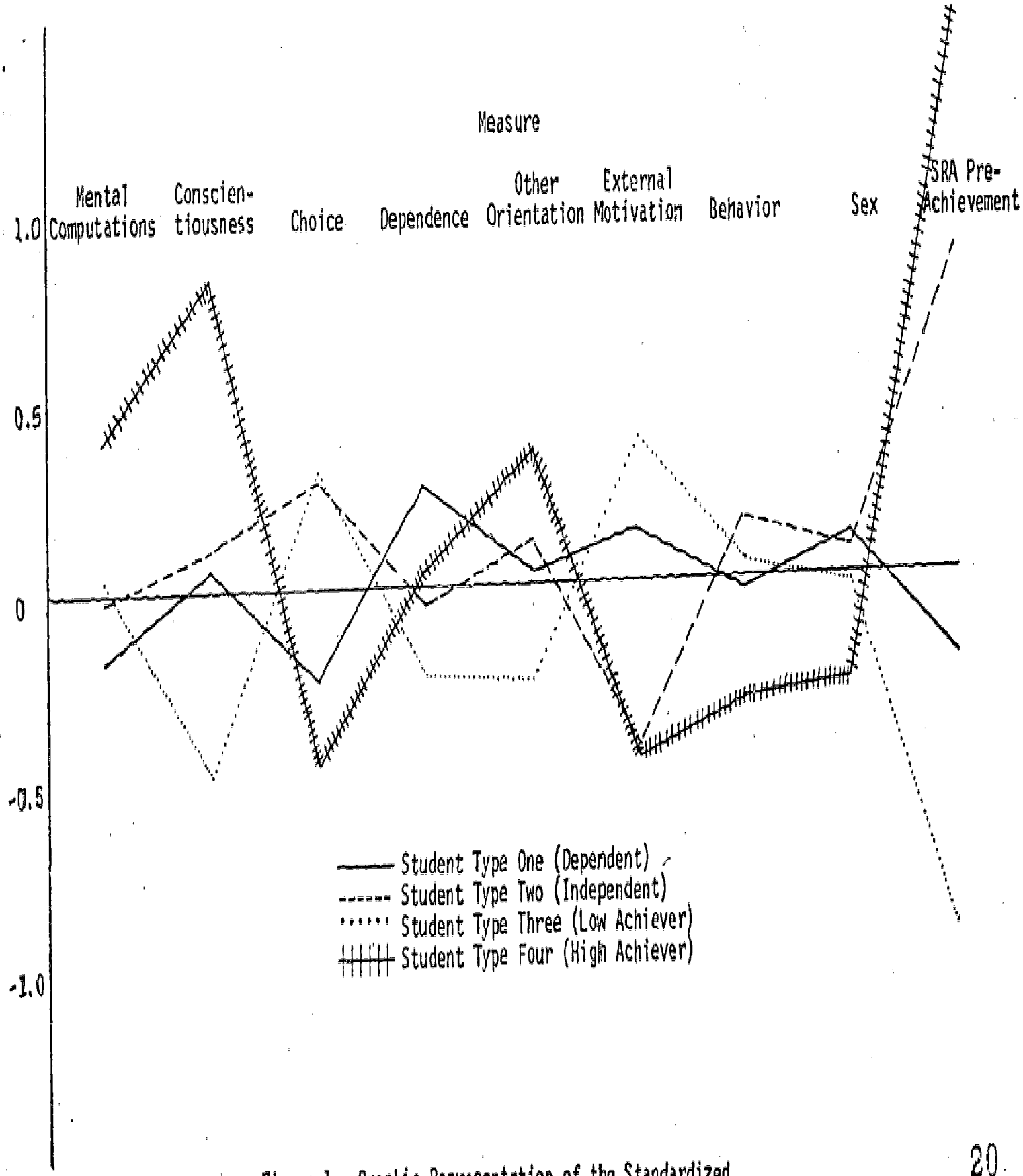

Figure 1: Graphic Representation of the Standardized Scores for Each of the Four Student Types

Student Type Two

Students in this typology scored considerably above average on prior math achievement. They tended to score about average on mental computations, conscientiousness, dependency and other orientation. Scores on the choice (high) and external motivation (low) scales indicated that students in typology two might be classified as independent. Their scores on the behavior scale indicated these students are the most frequent behavioral problems of the four student types. This seems to mesh with the independent label, as one could expect students who are slightly unconventional and who like a wide latitude of choice to clash with a teacher's idea of a well-behaved class. The moderate, although below average, score on the dependence scale is somewhat puzzling. It appears that although these students prefer a wide latitude of choice and are not especially affected by a teacher holding them accountable (i.e., by saying, "I'll check this work at the end of the period."), they seemingly still rely on the teacher to provide initial structuring of the lesson. Student typology two has been labeled *independent*.[2]

Student Type Three

Clearly the most salient feature of students in typology three is their extremely low prior math achievement. Scores on the other scales reflect what one would expect from low achievers: low conscientiousness, low on teacher structuring dependence, low on other orientation, high on need for external encouragement to finish their work, and above average on behavioral problems. Whether those traits cause, occur simultaneously, or are a result of low achievement

[2]Independent here refers to a behavioral preference to work alone and does not assume that the student has the concomitant skills necessary for working individually successfully.

is unknown. They do, however, appear to cluster together very nicely. Students in typology three appear to be somewhat withdrawn from the main flow of classroom life. For instance, they do not like to work with other children, nor do they especially depend on the teacher for structure. Their high preference for choice is possibly an attempt to avoid problems or situations that might be aversive, since they would likely fail most academic tasks that the teacher might afford. Student typology three has been labeled low achievement-withdrawn.

Student Type Four

Students constituting typology four are opposite in almost all traits from type three students. They are very high achievers who are conscientious, other oriented, require little external motivation to complete assignments, like to work problems in their heads, are infrequent behavioral problems and are more likely to be boys than girls. Interestingly, type four students scored the lowest on the choice scale. This may be due to their task orientation in which they perceive the teacher as leader of instruction. Student choice on tasks would tend to delay the completion of the job. Student typology four has been labeled high achievement-task oriented.

Teacher Types

Four teacher typologies emerged from the clustering procedure. The cluster profiles composed of the component means and standard deviations are included in Table 4, as are the F ratios, which indicate the degree to which each component differentiates the clusters. Teacher typology profiles are based on standardized scores are presented in Figure 2. Description of the four teacher types follow.

Teacher Type One

Teachers who constituted this typology tended to be younger, less experienced, and have little education beyond the bachelor's degree. They desired a moderate

degree of contextual stability in their classrooms and tended to present material in a non-abstract manner. Scores on need for personal control and degree of individualization were about average. They reported that they feel reasonably secure teaching mathematics. Teachers in typology one have been labeled less experienced/less educated.

Teacher Type Two

Type two teachers tended to have extensive teaching experience but had taken only a moderate amount of coursework beyond the bachelor's level. It appears that type two teachers have taken coursework needed to progress on the salary schedule but few, if any, additional graduate hours. Teachers in typology two scored low on degree of individualization and degree of security in teaching math. They scored moderate on the other scales (need for personal control, need for contextual stability) with the exception of the degree of abstractness where they indicated they present material in a slightly more abstract fashion. Teachers in typology two have been labeled experienced/unsure.

Teacher Type Three

Four qualities (need for personal control, degree of abstractness, amount of education, and degree of security) separated type three teachers from the remaining typologies. They reported a high degree of need for personal control of classroom rules, regulations, and instructional events. This feeling of personal control plus a high level of education may account for the high degree of security in teaching math that this typology reported. Interestingly, type three also reported the lowest degree of abstractness in their teaching approach. One might expect just the oppostie, that is, the more education a teacher has the more likely he or she would teach from a more theoretical or abstract point of view. A rival hypothesis, however, is that because of the high education level and thus increased knowledge

Table 4

Teacher Typologies Based on the Cluster Analysis: Means, Standard Deviations and F Ratios for Cluster Components

Teacher Typology		Components						
		Need for Personal Control	Need for Contextual Stability	Degree of Individualization	Degree of Abstractness	Degree of Security	Experience	Education
One (N=13)	Mean	20.00	27.53	18.53	13.61	17.84	15.30	13.15
	S.D.	2.51	5.69	6.50	2.63	1.34	7.99	5.88
Two (N=8)	Mean	20.00	26.87	16.75	17.37	14.50	27.25	35.50
	S.D.	2.07	5.56	3.05	1.50	1.60	10.63	17.09
Three (N=8)	Mean	22.00	24.75	18.62	12.25	19.00	23.62	42.87
	S.D.	2.61	5.25	5.47	2.65	1.41	13.19	23.64
Four (N=10)	Mean	17.60	21.30	22.20	19.20	15.10	17.60	17.30
	S.D.	2.83	5.18	6.69	5.73	2.96	8.66	14.17
Total (N=39)	Mean	19.79	25.23	19.12	15.53	16.69	20.05	24.89
	S.D.	2.87	5.82	5.92	4.41	2.59	10.66	19.22
F Ratio (3,36)		4.53***	2.77*	1.44	7.77***	10.89***	2.94**	8.35***

*p<0.10 **p<0.05 ***p<0.01

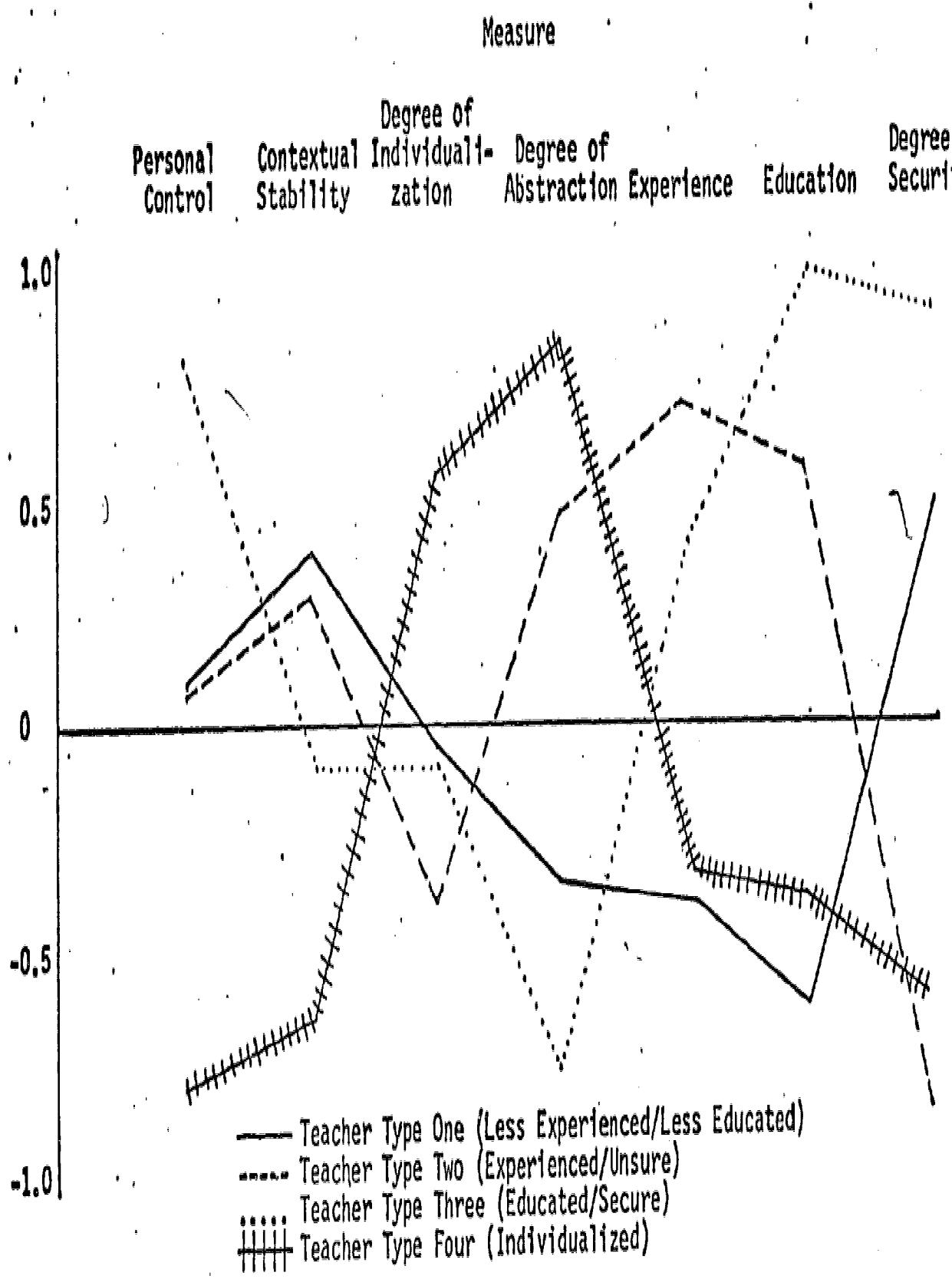

Figure 2: Graphic Representation of the Standardized Scores for Each of the Four Teacher Types

of the subject, the teacher might be able to dissect mathematics into easily understandable units and interlink those units into less abstract, but more meaningful lessons. Typology three teachers have been labeled educated-secure.

Typology Type Four

Typology four teachers portrayed characteristics typically associated with individualization. They had a low need for personal control and contextual stability, and they frequently allowed students to set classroom rules, assignments, and furniture placement, and the general direction of instruction. Of the four typologies, only type four teachers reported any degree of individualization in their classrooms. They also reported that they teach math more abstractly, with more emphasis on theory and less on "consumer skills." The experience and educational levels of type four teachers were below average, as was their security in math. Teachers in typology four have been labeled individualized.

Fidelity of Treatment Implementation

To assess the degree of implementation of the experimental treatment, coders collected low inference data concerning the presence, absence, or duration of specific instructional events outlined in the treatment. Although data gathered were low inference in nature, and thus not very susceptible to intercoder disagreement or drift, intercoder reliabilities for each coded category were determined and found to be good (90% or better agreement for each category). To derive a single measure representing overall implementation, a numerical score (based on the observational data) was calculated. The implementation scores for the experimental treatment and control, as well as the means and standard deviations, are presented in Table 5. Results of the analysis of variance comparing control and experimental teachers presented in Table 6 clearly indicate that the experimental teachers exhibited more of the treatment behaviors than did the control teachers.

Table 5

Means and Standard Deviation for the Implementation Scores

Treatment Condition	N	Mean	Standard Deviation	Minimum	Maximum
Experimental	20	9.06	1.35	7.45	12.44
Control	19	7.89	2.02	5.11	12.67

Table 6

Analysis of Variance between Experimental Treatment and Control Treatment Teachers' Implementation Scores

Source	df	MS	F	Probability
Treatment Condition	1	13.28	4.53	0.0400
Error	37	2.93		

Main and Interaction Effects

An analysis of variance procedure was used to test the statistical properties of the 4x4x2 factorial design. As can be seen from Table 8, all main and interaction effects among and between teacher types, student types and treatment types (control or experimental) were significant although at different levels. To determine the loci of the interaction effects, simple main effects were calculated and are reported in Table 9. The Newman-Keul multiple range test (adjusted for unequal N's) was used to indicate which particular student/teacher, student/treatment, or teacher/treatment pairings were causing the significant differences that were found in the simple main effect analysis.

Examination of Tables 10-18 reveals where these significant interactions occurred and can be summarized as follows:

1. Type one students (dependent) did significantly better with type two (experienced/unsure) and type three (educated/secure) teachers who were in the experimental treatment condition. They did significantly poorer with type three (educated/secure) teachers in the control treatment.
2. Type two students (independent) did significantly better with type three (educated/secure) teachers and significantly poorer with type four (individualized) teachers, both who were in the experimental treatment condition.
3. Type three students (low achievers) did significantly better with type two (experienced/insecure) and type three (educated/secure) teachers in the experimental treatment and poorest with type three (educated/secure) in the control.

4. Teacher type four (individualized) did worst with student type two (independent) in the experimental treatment condition. Individualized teachers did not do significantly better with any student type under either the treatment or control condition.
5. Teacher type three (educated/secure) did significantly better with student type four (high achievers) in the control but poorly with student types one (dependent) and three (low achievers), both in the control condition.
6. Type one students (dependent), who are in the experimental treatment, did best with teacher type two (experienced/unsure) and worst with teacher type one (less experienced/less educated).
7. Type two students (independent) and type three students (low achievers), who are in the experimental treatment did significantly better with teacher types three (educated/secure) and two (experienced/unsure). Independent students did poorly, on the other hand, with teacher type one (less experienced/less educated) and four (individualized).
8. Type four students (high achievers) did not do so significantly better under any teacher type.

Table 7

Number of Subjects, Means, and Standard Deviations for the Various Combinations of Teacher Types and Student Types in the Control Treatment Condition

Teacher Type		Student Type: Dependent	Independent	Low Achievers/ Withdrawn	High Achievers/ Task Oriented
Less Experience/ Less Education	N	71	36	58	28
	M	-0.95	-0.62	-0.93	-0.26
	SD	5.15	6.35	4.64	5.47
Experienced/ Unsure	N	51	20	29	15
	M	-1.24	-0.99	-1.58	2.32
	SD	5.20	5.57	4.11	5.21
Educated/ Secure	N	11	7	21	4
	M	-4.27	-1.65	-4.30	4.37
	SD	5.18	5.02	3.54	3.48
Individualized	N	46	47	37	40
	M	-2.77	-2.48	-1.85	-1.14
	SD	5.11	5.76	4.40	5.25

Table 7 (continued)

Number of Subjects, Means, and Standard Deviations for the Various Combinations of Teacher Types and Student Types in the Experimental Treatment Condition

Teacher Type		Student Type			
		Dependent	Independent	Low Achievers/ Withdrawn	High Achievers/ Task Oriented
Less Experience/ Less Education	N	30	13	38	5
	M	-0.72	-0.65	0.79	6.35
	SD	6.50	6.14	4.41	5.05
Experienced/ Unsure	N	44	22	33	17
	M	4.29	3.33	4.68	2.95
	SD	6.72	3.84	7.46	5.37
Educated/ Secure	N	59	31	25	27
	M	2.39	3.95	3.46	2.86
	SD	5.19	6.09	5.41	5.35
Individualized	N	38	15	55	4
	M	0.17	-6.25	-1.00	1.44
	SD	5.29	4.93	5.54	6.94

Table 8

Analysis of Variance
Dependent Variable--SRA Residual Score

Source	df	MS	F	Probability
Treatment Condition	1	1202.90	41.16	0.0001
Student Type	3	148.84	5.09	0.0018
Teacher Type	3	313.04	10.71	0.0001
Treatment x Student Type	3	63.64	2.18	0.0876
Treatment x Teacher Type	3	129.08	4.42	0.0045
Student Type x Teacher Type	9	51.49	1.76	0.0711
Treatment x Student Type x Teacher Type	9	70.92	2.43	0.0101
Error	945	29.22		

Table 9

Results of the Simple Main Effect Analysis

Source	df	MS	F	Probability
Student Type x Treatment Type at Teacher Type One	3	54.96	1.91	0.1271
Student Type x Treatment Type at Teacher Type Two	3	42.36	1.29	0.2764
Student Type x Treatment Type at Teacher Type Three	3	79.16	2.90	0.0361
Student Type x Treatment Type at Teacher Type Four	3	115.08	4.11	0.0072
Teacher Type x Treatment Type at Student Type One	3	141.01	4.62	0.0037
Teacher Type x Treatment Type at Student Type Two	3	168.81	5.23	0.0019
Teacher Type x Treatment Type at Student Type Three	3	184.43	7.06	0.0002
Teacher Type x Treatment Type at Student Type Four	3	44.56	1.56	0.1995
Student Type x Teacher Type at Treatment Type One	9	80.12	2.46	0.0097
Student Type x Teacher Type at Treatment Type Two	9	27.95	1.06	0.3897

Table 10

Newman-Keul Multiple Range Test on Differences between Student Types Under the Experimental Treatment and Control Treatment When Taught by Type Three Teachers (Educated/Secure)

		Student Type-Treatment Type								
		4. High Achievers in Control	2. Independent in Exp.	3. Low Achievers in Exp.	4. High Achievers in Exp.	1. Dependent in Exp.	2. Independent in Control	1. Dependent in Control	3. Low Achievers in Control	Critical Values
Student Type-Treatment Type	Means	4.37	3.95	3.46	2.86	2.39	-1.65	-4.27	-4.30	
4. High Achievers in Control	4.37		0.42	0.91	1.51	1.98	6.02*	8.64*	8.67*	
2. Independent in Experimental	3.95			0.49	1.09	1.56	5.60	8.22*	8.25*	R_2=4.1
3. Low Achievers in Experimental	3.46				0.60	1.07	5.11	7.73*	7.76*	R_3=4.9
4. High Achievers in Experimental	2.86					0.47	4.51	7.13*	7.16*	R_4=5.4
1. Dependent In Experimental	2.39						4.04	6.66*	6.69*	R_5=5.7
2. Independent in Control	-1.65							2.62	2.65	R_6=6.0
1. Dependent in Control	-4.27								0.03	R_7=6.2
3. Low Achievers in Control	-4.30									R_8=6.3

*p<0.05

Table 11

Newman-Keul Multiple Range Test on Differences between Student Types Under the Experimental Treatment and Control Treatment When Taught by Type Four Teachers (Individualized)

		Student Type-Treatment Type								
Student Type-Treatment Type	Means	4. High Achievers in Exp.	1. Dependent in Exp.	3. Low Achievers in Exp.	4. High Achievers in Control	3. Low Achievers in Control	2. Independent in Control	1. Dependent in Control	2. Independent in Exp.	Critical Values
		1.44	0.17	-1.00	-1.44	-1.85	-2.48	-2.77	-.625	
4. High Achievers in Experimental	1.44		1.27	2.44	2.88	3.29	3.92	4.21	7.69*	R_2=3.4
1. Dependent in Experimental	0.17			1.17	1.61	2.02	2.65	2.94	6.42*	R_3=4.1
3. Low Achievers in Experimental	-1.00				0.44	0.85	1.48	1.77	5.25*	R_4=4.5
4. High Achievers in Control	-1.44					0.41	1.04	1.33	4.81	R_5=4.8
3. Low Achievers in Control	-1.85						0.63	0.92	4.40	R_6=5.0
2. Independent in Control	-2.48							0.29	3.77	R_7=5.2
1. Dependent in Control	-2.77								3.48	R_8=5.4
2. Independent in Experimental	-6.25									

*p<.0.05

Table 12

Newman-Keul Multiple Range Test on Differences between Teacher Types Under the Experimental Treatment and Control Treatment Having Type One Students (Dependent)

		Teacher Type-Treatment Type								
Teacher Type-Treatment Type	Means	2. Experienced/ Unsure in Exp. 4.29	3. Educated/ Secure in Exp. 2.39	4. Individualized in Exp. 0.17	1. Less Experienced/ Less Education in Exp. -0.72	1. Less Experienced/ Less Education in Control -0.95	2. Experienced/ Unsure in Control -1.24	4. Individualized in Control -2.77	3. Educated/ Secure in Control -4.27	Critical Values
2. Experienced/ Unsure in Experimental	4.29		1.90	4.12*	5.01*	5.24*	5.53*	7.06*	8.56*	R_2=2.65
3. Educated/ Secure in Experimental	2.39			2.22	3.11	3.34	3.63	5.16*	6.66*	R_3=3.17
4. Individualized in Experimental	0.17				0.89	1.12	1.41	2.94	4.44	R_4=3.48
1. Less Experience/ Less Education in Experimental	-0.72					0.23	0.52	2.05	3.55	R_5=3.70
1. Less Experienced/ Less Education in Control	-0.95						0.29	1.82	3.32	R_6=3.86
2. Experienced/ Unsure in Control	-1.24							1.03	3.03	R_7=4.00
4. Individualized in Control	-2.77								1.50	R_8=4.11
3. Educated/Secure in Control	-4.27									

*p<0.05

Table 13

Newman-Keul Multiple Range Test on Differences between Teacher Types Under the Experimental Treatment and Control Treatment Having Type Two Students (Independent)

		Teacher Type-Treatment Type								
Teacher Type-Treatment Type	Means	3. Educated/ Secure in Exp.	2. Experienced/ Unsure in Exp.	1. Less Experience/ Less Education in Control	1. Less Experience/ Less Education in Exp.	2. Experienced/ Unsure in Control	3. Educated/ Secure in Control	4. Individualized in Control	4. Individualized in Exp.	Critical Values
		3.95	3.33	-0.62	-0.65	-0.99	-1.65	-2.48	-6.25	
3. Educated/ Secure in Experimental	3.95		0.62	4.57*	4.60	4.94	5.60*	6.43*	10.20*	R_2=3.76
2. Experienced/ Unsure in Experimental	3.33			3.95	3.98	4.32	4.98	5.82*	9.58*	R_3=4.50
1. Less Experienced/ Less Education in Control	-0.62				0.03	0.37	1.03	1.86	5.63*	R_4=4.93
1. Less Experienced/ Less Education in Experimental	-0.65					0.34	1.00	1.83	5.60*	R_5=5.24
2. Experienced/ Unsure in Control	-0.99						0.66	1.49	5.26*	R_6=5.48
3. Educated/Secure in Control	-1.65							0.83	4.60*	R_7=5.67
4. Individualized in Control	-2.48								3.77*	R_8=5.83
4. Individualized in Experimental	-6.25									

*p<0.05

Table 14

Newman-Keul Multiple Range Test on Differences between Teacher Types Under the Experimental Treatment and Control Treatment Having Type Three Students (Low Achievers)

		Teacher Type-Treatment Type								
		2. Experienced Unsure in Exp.	3. Educated/ Secure in Exp.	1. Less Experience/ Less Education in Exp.	1. Less Experience/ Less Education in Exp.	4. Individualized in Exp.	2. Experienced/ Unsure in Control	4. Individualized in Control	3. Educated/ Secure in Control	Critical Values
Teacher Type-Treatment Type	Means	4.68	3.46	0.79	-0.93	-1.00	-1.58	-1.85	-4.30	
2. Experienced/ Unsure in Experimental	4.68		1.22	3.89*	5.61*	5.68*	5.26*	5.53*	8.98*	R_2=2.43
3. Educated/Secure in Experimental	3.46			2.67*	4.39*	4.46*	5.04*	5.31*	7.76*	R_3=2.91
1. Less Experienced/ Less Education in Experimental	0.79				0.14	1.79	2.37	2.64	5.09*	R_4=3.19
1. Less Experienced/ Less Education in Control	-0.93					0.07	0.65	0.92	3.37*	R_5=3.39
4. Individualized in Experimental	-1.00						0.58	0.85	3.30*	R_6=3.54
2. Experienced/ Unsure in Control	-1.58							0.73	2.72	R_7=3.66
4. Individualized in Control	-1.85								2.45*	R_8=3.77
3. Educated/Secure in Control.	-4.30									

*p<0.05

Table 15

Newman-Keul Multiple Range Test on Differences between Teacher Types When Teaching Type One Students (Dependent) in the Experimental Treatment

		Teacher Type				
		2. Experienced/ Unsure	3. Educated/ Secure	4. Individualized	1. Less Experienced/ Less Education	Critical Values
Teacher Type	Means	4.29	2.39	0.17	-0.72	
2. Experienced/ Unsure	4.29		1.90	4.12*	5.01*	R_2=2.48
3. Educated/ Secure	2.39			2.22	3.11*	R_3=2.97
4. Individualized	0.17				0.89	R_4=3.26
1. Less Experienced/ Less Education	-0.72					

*p<0.05

Table 16

Newman-Keul Multiple Range Test on Differences between Teacher Types When Teaching Type Two Students (Independent) in the Experimental Treatment

		Teacher Type				
		3. Educated/ Secure	2. Experienced/ Unsure	1. Less Experienced/ Less Education	4. Individualized	Critical Values
Teacher Types	Means	3.95	3.33	-0.65	-6.25	
3. Educated/ Secure	3.95		0.62	4.60*	10.20*	R_2=3.68
2. Experienced/ Unsure	3.33			3.98*	9.58*	R_3=4.40
1. Less Experienced/ Less Education	-0.65				5.60*	R_4=4.84
4. Individualized	-6.25					

*p<0.05

Table 17

Newman-Keul Multiple Range Test on Differences between Teacher Types When Teaching Type Three Students (Low Achievers) in the Experimental Treatment

		Teacher Type				
Teacher Type	Means	2. Experienced/ Unsure	3. Educated/ Secure	1. Less Experienced/ Less Educated	4. Individualized	Critical Values
		4.68	3.46	0.79	-1.00	
2. Experienced/ Unsure	4.68		1.22	3.89*	5.68*	R_2=2.65
3. Educated/ Secure	3.46			2.67*	4.46*	R_3=3.17
1. Less Experienced/ Less Education	0.79				1.79	R_4=3.49
4. Individualized	-1.00					

*p<0.05

Table 18

Newman-Keul Multiple Range Test on Differences between Teacher Types When Teaching Type Four Students (High Achievers) in the Experimental Treatment

		Teacher Type				
Teacher Type	Means	1. Less Experienced/ Less Education	2. Experienced/ Unsure	3. Educated/ Secure	4. Individualized	Critical Values
		6.35	2.95	2.86	1.44	
1. Less Experienced/ Less Education	6.35		3.40	3.49	4.91	R_2=5.81
2. Experienced/ Unsure	2.95			0.09	1.51	R_3=6.52
3. Educated/ Secure	2.86				1.42	R_4=7.64
4. Individualized	1.44					

*p<0.05

- Discussion

The direct instruction model used in this study proved effective and substantiated earlier reviews of correlational research and the findings of others (e.g., Rosenshine, 1977; Medley, 1977; Anderson, Evertson and Brophy, in press; Bloom, 1976; Bennett, et al., 1976; and Crawford and Stallings, 1978). The large main effect produced by the experimental treatment in this study lends support to the direct instruction paradigm (see Good and Grouws, 1978, and Good, in press, for a more detailed discussion of main effects), and to the contention that teachers can and do make a difference in student learning (Good, Biddle, and Brophy, 1975; Gage, 1978).

The interactions among student type, teacher type and treatment type produce findings which also allow a meaningful interpretation. For instance, type three (educated/secure) teachers were quite successful with dependent and low achieving students who were in the control treatment. On the other hand, they did best with high achieving students in the control group. Type three teachers are likely to be subject orientated, thus likely to place more emphasis on accomplishment than social concerns; therefore, this finding seems reasonable. Low achieving students are likely to get lost in an environment that stresses achievement without lesson structure. Dependent students need more attention and specification than they are likely to get in an achievement-orientated environment. Interestingly, as one would predict, low achievement and dependent students in the experimental treatment do significantly better. This is possibly due to the treatment's emphasis on review (which increases exposure to content), homework (which provides needed practice), and increased structure (which reassures, to some extent, dependent children).

Type four teachers (individualized) were relatively ineffective with all student types and especially with student type two (independent) in the experimental treatment and, to a lesser extent, type two students in the control. Although

this finding may seem contrary to "conventional wisdom," it is not. Student type two was labeled as behaviorally independent, but it does not follow that independent students can effectively structure their time to meet goals set by the teacher. They are just as likely to direct their attention and efforts to non-teacher-sanctioned events. A clear indication of this possible non-academic orientation is the relatively high degree of behavioral problems reported by independent students. Type four (individualized) teachers may allow much latitude in choice, and it becomes dysfunctional, especially for students who are likely to "take advantage" of the situation.

Type one students (dependent) do best with type two teachers (experienced/unsure) in the experimental treatment condition and, to a lesser extent type three teachers (educated/secure) also in the experimental treatment condition. On the other hand, they do poorest with type three teachers (educated/secure) in the control group. The relationship between student type one and teacher type three has been discussed previously, however, the discovery that experienced/unsure teachers in the experimental treatment do best with dependent students is new. This finding seems to add support to those who advocate matching students and teachers on the basis of their similarity of characteristic (See Cronback and Snow, 1977). It would seem natural that a symbiotic relationship would develop between a teacher who lacks security in teaching math and a student who needs teacher support.

Unsure teachers also seem to benefit extensively from the experimental treatment program. Apparently, the structured program provides these teachers with the direction they lacked and for which, perhaps, they were searching. Interestingly, experienced/unsure teachers did consistently better in the experimental treatment, regardless of the student type they taught.

Type two students (independent) do best with type three teachers (educated/secure) in the experimental treatment whereas, they do very poorly with type

four (individualized) in the experimental treatment condition. The rationale for the poor performance of type two students (independent) when paired with type four teachers (individualized) in the experimental treatment seems to stem from a lack of student academic involvement, due to poor implementation of the program by these teachers.

The explanation of why independent students do best with educated/secure teachers in the experimental treatment seems to correspond nicely with the academic involvement hypothesis suggested above. Since independent students are less conforming to teacher expectations and sanctions, it is clear that they need firm encouragement to stay on task as defined by the teacher. Clearly, teacher type three (educated/secure) would be likely to provide such task direction and, therefore, do better with independent students. The experimental treatment serves to further enhance this task emphasis.

The last teacher type by treatment type interaction that was significant occurred with type three students (low achievers). Students in type three (low achievers) do substantially better with teacher types two (experienced/insecure) and type three (educated/secure), in the experimental treatment. Conversely, they do the poorest with type three teachers in the control treatment. The relationship between teacher type three and student type three has been previously discussed. The new finding that low achievers do best with type two teachers (experienced/unsure) in the experimental treatment again seems to support the idea of matching student-teacher characteristics for optimal growth. In this case, the matched characteristic would be insecurity in mathematics. However, simple matching does not entirely portray the picture, otherwise, teacher type two (experienced/unsure) in the control condition would also produce large student gains. The fact that little gain resulted indicates the mediating effect of the experimental treatment. Seemingly, the increased structure and direction afforded by the experimental treatment has a positive effect on both the teacher and the student. The student

probably benefits most from the increased practice and review session, while the teacher benefits from the increased direction that comes from greater organization.

One of the more interesting findings of this study was the interactions between teacher type and treatment type. There exists a strong teacher effect in the treatment condition that is not found in the control sample. This interaction occurs for type two (experience/unsure) and three (educated/secure) teachers but not for teacher types one and four. An examination of the mean implementation scores for the teacher types in the treatment group revealed that teacher types two and three significantly implemented more of the treatment behaviors than did teachers types I and IV (Means: Type 1 = 8.48, Type 2 = 9.82, Type 3 = 9.64, Type 4 = 8.25). The data collectively suggest that teachers who implement the treatment get good results, yet, some teacher types choose to use more of the facets of the program than other teacher types.

Since people will more likely adopt and internalize ideas that are consonant with their existing belief system one could predict that teachers who already believed in a direct instructional model, as called for in the experimental treatment program, or teachers who were unsure using their present instructional strategies would be more likely to implement the experimental treatment program if requested to do so. Thus, for example, teacher type three (educated/secure) in this study, who indicated they teach in a more direct manner, would be more likely to employ the experimental treatment program than teacher type four who prefer to teach using an individualized model. Similarly, teacher type two (experienced/unsure) would probably enhance the treatment because it resembles the "old" method of teaching with which they are familiar, and because they indicate they are currently insecure teaching math in the present manner. Teacher type one (less experienced/less educated), on the other hand, showed a high degree of security in teaching

in the present manner, therefore, they would not be likely to change without additional and more specific training to show them how to change.

The reasons that some teacher types chose to use the experimental treatment and others did not are important for future experimental studies. In particular, if researchers or school officials were interested in maximizing student gain but limited in resources and/or time, it would be beneficial to select teachers who would interact with the treatment to produce the desired effect. Alternatively, it would be desirable to explore ways to make the treatment more understandable and meaningful to type I and type IV teachers who were found to implement the treatment less in the present study.

Teachers can and do make a difference. Any attempt to design, test and implement an instructional program must be cognizant of this fact (See Good, Biddle and Brophy, 1975; and Gage, 1978, for a further discussion).

The results of this study also lend support to the ATI paradigm. Interactions between and among student, teacher and treatment types appear to be real and important. There are some students who perform about as well under one type of teacher as another, while others do better in the experimental treatment and/or with a particular teacher type. In general, results from this study tend to support the matching model theory (Hunt, 1968; Cunningham, 1976; and Soloman and Kendall, 1976) which suggests that if student characteristics are matched with similar program and teacher characteristics, achievement will be enhanced. (For a more detailed discussion see Ebmeier, 1978).

The small sample size in some cells demands that considerable caution be exercised in any attempt to generalize the results of this study. In addition, the reader must remember that the teacher and student data were gathered using instruments that employed a self-reporting system, therefore, they may not represent actual student dispostions or teacher characteristics. The long term

stability of the student and teacher typologies are also unknown at this point and if found to be unstable in future investigations would place additional limitation on this study.

Despite these limitations, however, the number and magnitude of the interactions found in this study offer convincing evidence that interactions between and among student types, teacher types and treatment types exert influence on students-mathematics achievement. In addition, the present study substantiates the value of the research methodology employed by Cunningham (1976), Solomon and Kendall (1976) and Bennett (1975) and others who have moved from a unidimensional to a multidimensional aptitude model. Although complexities do arise from such a shift, they can be reduced by clustering teachers and students into groups with similar characteristics. Once clustered, these teacher and student typologies can be conceptually defined in terms of patterns of behavior, which ultimately make more sense than isolated behaviors. The scarcity of ATI findings (Bracht, 1970) in previous research may have been due in part to this tendency to focus on single aptitude variables and ignore complex relationships among the other classroom variables.

Further studies in this area probably need to make methodological adjustments in two areas. First, the direct instruction treatment program utilized in this research needs to be modified such that teachers who are uncomfortable or who do not understand some of the teaching requests can still accommodate them into their teaching style. Although the results presented here lend support in favor of the direct instruction's general effectivensss in increasing student mathematics achievement, future studies need to include outcome measures in other diverse areas.

Secondly, future ATI studies of this nature need to verify by classroom observations the existence of the derived student and other teacher typologies. Although studies to date which placed students and teachers into typologies chiefly

by pen and paper instruments have found important results, it is useful to also gather some clinical data from which explanatory theories could develop.

Although several studies have examined teacher type-student type interactions they have generally employed different populations or measures. It, therefore, seems useful in the immediate future to encourage exploratory studies in this area even though they might be overlapping in nature. Eventually an integration of the different typologies must take place subsequently followed by extensive validation procedures. Researchers who have already conducted exploratory studies similar to this one need to follow up their initial naturalistic findings by moving to an experimental design whereby students are selectively placed in classrooms which are thought to be advantageous.

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